

# Part III

## Application Fields, Case Studies and Examples

### Model Applications to Understand Complex Ecological Dynamics

In the previous section of this book, the most common and important modelling approaches for ecological purposes were introduced. The following section will focus on application examples from ecological systems in different regions of the world, which demonstrate how models contribute to a large variety of issues in basic and applied research in ecology. With the given examples we intend to give a motivating insight into the wide field of model applications, from small scale population processes to landscape representations involving a combination of different approaches and techniques. Thus, the examples contain both detailed research results and for specific systems, an overview of model applications. Although the examples refer to a wide set of different ecological systems, they all require an approach to deal with complex dynamic behaviour.

### *Hypothesis Testing on the Landscape Level*

Spatial patterns in landscapes can be assessed from two different perspectives: first, as a result of interactions of the underlying biotic and abiotic processes, and second, as influenced by the constraints that direct and modify the underlying interactions. This mutual dependence is further complicated by the permanent change in land use conditions, which often leads to habitat loss and fragmentation. Here, models can be of great help to answer hypotheses on causes, effects and potential future developments. For this purpose, a neutral perspective is often adopted, meaning that the model generates characteristic spatial patterns without considering specifically targeted mechanisms referring to underlying ecological processes. In this sense, these kinds of models are used as a null hypothesis to test deviations in the empirical data from theoretical expectations.

In **Chap. 15, Gardner** outlines the historical development of this approach for Landscape Ecology. He explains the working principles and presents a case study from the North-American Piedmont Forests in Maryland.

The role of dispersal and how it can be formalised by using different dispersal kernels is the topic of **Chap. 16** by **Garnier and Lecomte**, which tests hypotheses on the conditions that support the survival of organisms in structured landscapes. They explain models that have been developed to understand the spread of oilseed rape along road verges and the invasion of grasslands by pines. The models are applicable largely for European and Northern-American habitats.

In **Chap. 17**, **Kubicek and Borell** investigate the importance of path dependency and ecosystem phase shifts for tropical coral reefs, which are among the most diverse ecosystems worldwide and are currently severely threatened by anthropogenic impacts. Here, standard model types are reviewed on how effectively they can be used to understand the main driving forces of tropical coral reefs, interacting sensitively between resilience and phase shifts.

### ***Environmental Management and the Integrative Power of Modelling***

Modelling plays an increasingly important role for management and ecological conservation. When phenomena are investigated that occur over a wide range of hierarchical ecosystem levels or over several spatial and temporal scales, modelling is often the only solution to analyse and understand the ongoing dynamics. Furthermore, applying empirical experiments on the landscape level is not always a possible option. In this context, ecological modelling offers many possibilities for management and planning. Moreover, ongoing research models collect data that derive from many different sources, sometimes over decades, and display different statistical properties.

In **Chap. 18**, **Jopp, DeAngelis and Trexler** investigate the possible consequences of changing and reducing the water table in the fluctuating marshlands of the South-Florida Everglades and how changes may affect the trophic structure.

A special contribution is **Chap. 19** by **Nielsen and Jørgenson** which presents a case study on the modelling activities on the Danish post-glacial Lake Glumsø. Here, the advancements of ecological modelling can be seen over more than three decades: moreover, this research project had profound impacts on the advancement of ecological modelling as a scientific discipline.

In **Chap. 20** **Gallego** uses model-coupling to understand the complex dynamics of marine zoo- and ichthyoplankton and what importance these dynamics have for the dramatic stock collapses of cod in the Northern Atlantic.

In **Chap. 21**, **Jopp and DeAngelis** demonstrate the integrative power of modelling for the comprehensive Everglades restoration plan. The plan aims to support the recovery of many endangered species and biodiversity of the overall landscape of the Everglades and its neighbouring ecosystems in southern Florida. Here, ecological modelling plays a central role for science-based decision making, and hence, ecosystem restoration.

In **Chap. 22, Kraft** focuses on integrated modelling: He describes how models from different disciplines are coupled and their complex results are aggregated into a modelling framework, for which Geographical Information Systems (GIS) are commonly used. The author brings several application examples from catchment models and models that are dealing with coastal and marine landscapes.

The eight contributions in this section illustrate how to use models to understand complex problems and issues that could not easily be grasped otherwise. Although we present the chapters in a sequence following complexity considerations, you, the reader, should feel free to use any starting point that suits your preferences as the chapters represent independent cases.